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P/ ENT COOPERATION TREAT

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

BIRD, William
Bird Göen & Co.
Vilvoordsebaan 92
B-3020 Winksele
BELGIQUE

Date of mailing (day/month/year)
25 September 2000 (25.09.00)

Applicant's or agent's file reference
N1393-PCT

IMPORTANT NOTIFICATION

International application No.
PCT/EP99/08273

International filing date (day/month/year)
29 October 1999 (29.10.99)

1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [X] the agent [ ] the common representative

Name and Address
BIRD, William
Bird Göen & Co.
Termerestraat 1
B-3020 Winksele
Belgium

State of Nationality:
State of Residence:
Telephone No.: +32-16-48.05.62
Facsimile No.: +32-16-48.05.28
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address
BIRD, William
Bird Göen & Co.
Vilvoordsebaan 92
B-3020 Winksele
Belgium

State of Nationality:
State of Residence:
Telephone No.: +32-16-48.05.62
Facsimile No.: +32-16-48.05.28
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
A. Karkachi

Telephone No.: (41-22) 338.83.38

P ENT COOPERATION TREA

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 06 July 2000 (06.07.00)	
International application No. PCT/EP99/08273	**Applicant's or agent's file reference** N1393-PCT
International filing date (day/month/year) 29 October 1999 (29.10.99)	**Priority date** (day/month/year) 06 November 1998 (06.11.98)
Applicant FAUCONNIER, Denis	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

26 May 2000 (26.05.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Pascal Piriou

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

BIRD, William
Bird Göen & Co.
Vilvoordsebaan 92
B-3020 Winksele
BELGIQUE

Date of mailing (day/month/year)
29 March 2001 (29.03.01)

Applicant's or agent's file reference
N1393-PCT

IMPORTANT NOTIFICATION

International application No.
PCT/EP99/08273

International filing date (day/month/year)
29 October 1999 (29.10.99)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address

NORTEL NETWORKS LIMITED
1, place des Frères Montgolfier
F-78928 Guyancourt Cedex 9
France

State of Nationality: FR
State of Residence: FR
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [ ] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address

NORTEL NETWORKS LIMITED
World Trade Center
380 St. Antoine Street West, 8th Floor
Montreal, Québec H2Y 3Y4
Canada

State of Nationality: CA
State of Residence: CA
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
Eugénia Santos

Telephone No.: (41-22) 338.83.38

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

5

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
N1393-PCT		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/08273	29/10/1999	06/11/1998
International Patent Classification (IPC) or national classification and IPC H04L1/06		
Applicant NORTEL MATRA CELLULAR et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 12 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
26/05/2000	03.11.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Dechmann, J-L Telephone No. +49 89 2399 8826

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/08273

I. Basis f th r port

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1,7-14	as originally filed			
2-5,6a-6b	as received on	19/10/2000	with letter of	17/10/2000

Claims, No.:

1-25	as received on	19/10/2000	with letter of	17/10/2000

Drawings, sheets:

1/6-6/6	as originally filed

2. The amendments have resulted in the cancellation of:

☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1-25
	No:	Claims
Inventive step (IS)	Yes:	Claims 1-25
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1-25
	No:	Claims

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1

The following documents have been considered for the purposes of this report:

D1: US-A-4 447 903

D2: IEEE TRANSACTIONS ON COMMUNICATIONS, vol. 38, no. 9, BENELLI G: "TWO NEW CODING TECHNIQUES FOR DIVERSITY COMMUNICATION SYSTEMS", 1 September 1990, pages 1530-1538, XP000173221

D3: IEICE TRANSACTIONS, vol. E74, no. 6, MATSUMOTO T ET AL: "COMBINED CONVOLUTIONAL CODING/DIVERSITY RECEPTION FOR QDPSK LAND MOBILE RADIO", 1 June 1991, pages 1522-1530, XP000262309

D4: IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, vol. 13, no. 2, TSUTOMU SAKAI ET AL: "SOFT-DECISION VITERBI DECODING WITH DIVERSITY COMBINING FOR MULTI-BEAM MOBILE SATELLITE COMMUNICATION SYSTEMS", 1 February 1995, pages 285-290, XP000489292

D5: US-A-5 657 325

The following documents were not cited in the international search report.

D6: US-A-5 416 787

D7: US-A-5 668 820

D8: US-A-5 691 992

II

The present invention relates to the protection of information bits, being transmitted within a telecommunications system.
Forward Error correction (FEC) is known in which errors in the transmitted digital signal are corrected without re-transmitting the same signal. The number of additional bits to provide reliable correction can be high which reduces the throughput of the system drastically. To reduce the reduction in capacity caused by the additional correction bits, the number of bits may be reduced by puncturing in which a certain portion of bits from the FEC are removed. This reduces the quality and reliability of the error correction but increase the data rate.

D5 discloses puncturing and sending messages along different paths but the messages along the two paths are not substantially the same nor are they sent simultaneously. The bits sent along the second path are only the punctured bits not sent along the first path. They are also only sent after a negative acknowledgement. This procedure is very slow. It requires that the first message is stored in the receiver until the punctured bits arrive. This prevents real-time processing as would be required for voice communications.
The teaching of D5 is therefore that puncturing is a problem which can be so severe that it is necessary to reconstitute the received message by sending the punctured bits after the main message. This results in the complete message being sent over different channels in sequence. Effectively, this reference teaches that puncturing creates a problem which is best solved by sending the complete message if the interference is bad.

The reference D1 only discusses how to improve reception by sending two messages over two different channels. The data rate of the information remains the same as each bit in the original message is combined with a bit a predetermined distance away. The method does not use non-information bits and therefore the data rate is less than is achieved with more complex coding schemes. However, this simplified coding scheme also has the disadvantage that the more complex multiple error corrections cannot be carried out. Further, this document does not suggest or hint at the use of puncturing to

enhance forward error coding.
The citation D2 requires two full decoders in series (Figure 3) - a significant disadvantage compared to the present invention. The method makes use of the concatenation of two complex coding procedures in order to improve reception. There is no indication that the data rate is reduced. There is no hint or suggestion that puncturing can improve reception.

None of the prior art documents cited, therefore, use two substantially identical signals which are punctured with a different number of bits to provide enhanced forward error coding.
An inventive step is therefore acknowledged.

Claim 1: Method of transmitting
Claim 6: Method of receiving
Claim 10: Transmitter
Claim 11: System with transmitters and receivers
Claim 13: Receiver
Claim 22: Mobile terminal comprising a receiver
Claim 23: Mobile terminal comprising a transmitter
Claim 24: Coder
Claim 25: Decoder
The requirements of conciseness are therefore fulfilled in this particular case.

VII. Certain defects in the international application

1. All the claims should be grouped together to the extent and in the most appropriate way possible. The arrangement must therefore be one which enables the association of related claims to be readily determined and their meaning in association to be readily construed (cf. PCT Guidelines C-III-3.6).
   On this point, method claims 16-21 should be moved to the beginning together with methods claim 1-9 and should not be located at the end after all the system claims.

2. The reference to the "spirit" of the invention should be deleted on page 13 (PCT Guidelines C-III-4.3a and Article 6 PCT).

3. The opportunity should be taken to correct a clerical error on page 13, line 11: comparitor should read comparator.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
N1393-PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 99/08273	29/10/1999	06/11/1998
Applicant		
NORTEL MATRA CELLULAR et al		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 2

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
P[redacted]P 99/08273

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L1/06 H04L1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H03M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 4 447 903 A (SEWERINSON AKE N) 8 May 1984 (1984-05-08) abstract column 1, line 50 -column 2, line 10 column 3, line 23 - line 26 figure 4 --- -/--	1,2,6,9, 10,14 17

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 January 2000	04/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Langinieux, F

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	BENELLI G: "TWO NEW CODING TECHNIQUES FOR DIVERSITY COMMUNICATION SYSTEMS" IEEE TRANSACTIONS ON COMMUNICATIONS, vol. 38, no. 9, 1 September 1990 (1990-09-01), pages 1530-1538, XP000173221	1,2,6,9, 10,14,18
A	abstract * section I * * section II * figure 2	8,16
A	MATSUMOTO T ET AL: "COMBINED CONVOLUTIONAL CODING/DIVERSITY RECEPTION FOR ODPSK LAND MOBILE RADIO" IEICE TRANSACTIONS, vol. E74, no. 6, 1 June 1991 (1991-06-01), pages 1522-1530, XP000262309 abstract * section I * * section II *	1-3, 8-11,14, 16
A	TSUTOMU SAKAI ET AL: "SOFT-DECISION VITERBI DECODING WITH DIVERSITY COMBINING FOR MULTI-BEAM MOBILE SATELLITE COMMUNICATION SYSTEMS" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, vol. 13, no. 2, 1 February 1995 (1995-02-01), pages 285-290, XP000489292 abstract * section II * figures 1,3	1-3, 8-11,14, 16
A	US 5 657 325 A (LOU HUI LING ET AL) 12 August 1997 (1997-08-12) cited in the application abstract figure 4	1-7,9-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
[redacted]EP 99/08273

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4447903 A	08-05-1984	CA 1180074 A	25-12-1984
US 5657325 A	12-08-1997	US 5689439 A	18-11-1997
		CA 2172320 A	01-10-1996
		EP 0735701 A	02-10-1996
		CA 2171998 A	04-10-1996
		EP 0736979 A	09-10-1996
		JP 8288934 A	01-11-1996

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04L 1/06, 1/00

A1

(11) International Publication Number: WO 00/28692

(43) International Publication Date: 18 May 2000 (18.05.00)

(21) International Application Number: PCT/EP99/08273

(22) International Filing Date: 29 October 1999 (29.10.99)

(30) Priority Data:
98402761.5 6 November 1998 (06.11.98) EP

(71) Applicant *(for all designated States except US)*: NORTEL MATRA CELLULAR [FR/FR]; 1, place des Frères Montgolfier, F–78928 Guyancourt Cedex 9 (FR).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: FAUCONNIER, Denis [FR/FR]; 13, avenue Guy de Coubertin, F–78470 Saint–Remy Lès Chevreuse (FR).

(74) Agents: BIRD, William et al.; Bird Göen & Co., Termerestraat 1, B–3020 Winksele (BE).

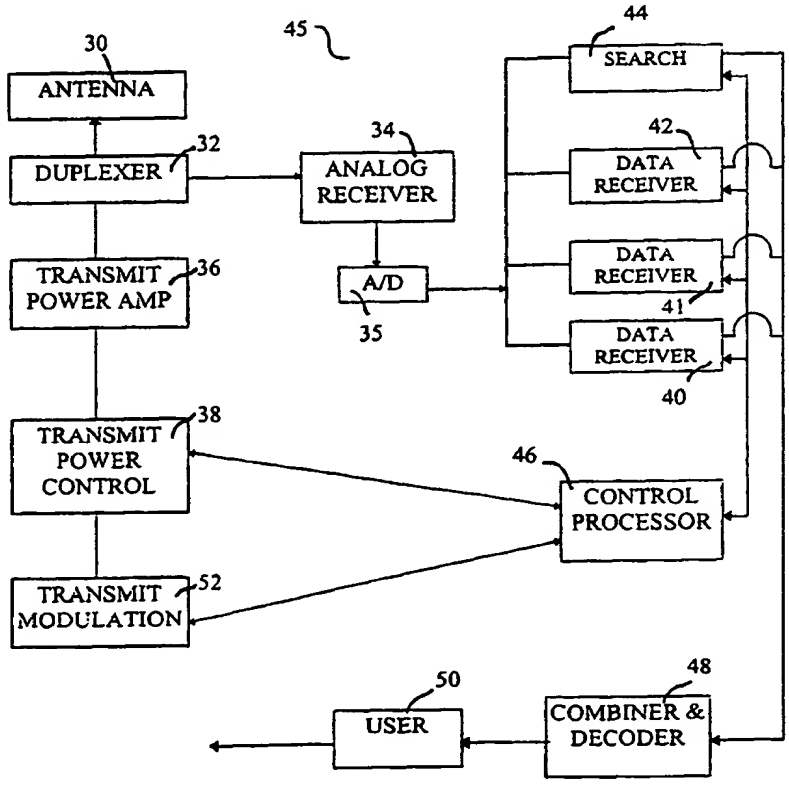
(81) Designated States: BR, CA, CN, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR PROVIDING HIGH QUALITY TRANSMISSIONS IN A TELECOMMUNICATIONS SYSTEM

(57) Abstract

A mobile radio telecommunications system is described in which the same user message is transmitted with forward error correction (FEC) codes on three separate channels to a receiver (45). The FEC codes for the three signals are different, e.g. different bits are punctured in the first signal compared with the second signal and so on. The receiver (45) includes a plurality of data receivers (40–42) for extracting the received signals as well as a forward error correction decoder (48) for substantially simultaneously decoding the differently forward error correction coded signals. The extracted decoded signals can be used individually or combined in a variety of ways to improve reception.



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which reduces the throughput of the system drastically. However, where a high level of quality is required and retransmission cannot be tolerated, the methods are most useful. To reduce the reduction in capacity caused by the additional correction bits the number of bits may be reduced by "puncturing" in which a certain proportion of bits from the forward error coded signal are removed. This reduces the quality and reliability of the error correction but increases the data rate.

Combinations of the above are also used. For example, US 5,657,325 describes a combined ARQ and FEC technique in which a signal is error coded, punctured and then transmitted over a first radio channel from one antenna to a receiver and on receiving a negative acknowledgment from the receiver (the signal cannot be corrected properly at the receiver), the relevant punctured bits are sent via a second antenna, i.e. via a separate channel which may have better transmission quality or may introduce different or less troublesome errors. The disadvantage of this technique is that even retransmission of only the punctured bits introduces temporal latency into the transmission which is often unacceptable, e.g. in voice transmissions in which no delay can be tolerated. Further, it is not possible to reconstruct the complete message from the punctured bits alone and the first message must always be used in the reconstruction attempt. It is therefore possible that if the originally received message contains very many errors it is not possible to reconstruct an accurate copy of the transmitted message.

Cellular telecommunications systems often include some form of compression of voice messages, e.g. a Vector Sum Excited Linear Prediction (VSELP) speech coder, convolutional coding for error protection, some form of modulation, e.g. differential quadrature phase shift keying (QPSK) modulation, and some form of access scheme, e.g. a time division, multiple access (TDMA) scheme or a Code Division Multiple Access (CDMA) scheme employing a frame subdivided into a number of time slots per carrier frequency.

In one known standardized system the error protection scheme utilizes the well known half rate convolutional channel encoder. The half rate convolutional channel encoder adds redundancy to the compressed speech data by using a shift register, generating two output bits for every input bit, and multiplexing the output bits to form the output. The generation of each output bit is done by a weighted modulo 2 sum of the input bit and the shift register contents according to a predefined generator polynomial. The number of memory elements in the shift register plus one is referred to as the

constraint length of the convolutional coder. The initial state of the shift register is zeroed out, and the final state is also guaranteed to be zero by flushing it with five tail or flush bits of "0" after every input block of compressed speech data.

The VSELP speech codec puts out 159 compressed speech bits every 20 ms. These bits are divided into two classes. Class 1 bits are bits that are perceptually more significant and therefore require error protection. This is accomplished by the half rate convolutional channel codec with constraint length 6. Class 2 bits are bits that are not as significant as their Class 1 counterparts and are given no error protection. There are 77 Class 1 bits and 82 Class 2 bits. Among the Class 1 bits, there are a few bits that are perceptually the most significant, and it is important that they have error detection capability as well. This is accomplished by using a 7-bit cyclic redundancy check (CRC) over the twelve most perceptually significant bits. The 77 Class 1 bits, the 7 CRC bits, and the 5 tail bits are fed into the convolutional encoder to generate 178 coded bits. These are then fed along with the Class 2 bits into an interleaving array of dimension 26x10, interleaved row-wise with the interleaving array of the previous 20 ms frame, and transmitted row-wise after interleaving.

At the receiving station, de-interleaving is first accomplished to yield the 26x10 array of coded Class 1 and Class 2 bits of the previous 20 ms VSELP frame. After extracting the 178 coded Class 1 bits, the 77 Class 1 bits and 7 CRC bits are decoded using the Viterbi algorithm, which is a special case of dynamic programming. The locally generated 7 CRC bits are compared to the received 7 CRC bits to provide a bad frame indication to the VSELP speech decoder. The error correcting capacity can be increased by increasing the constraint length, but this comes with an exponential increase in cost or complexity of the Viterbi decoder. Known in the art in the use of forward-error-correction that includes convolutional encoding in the transmission of encoded digital data over a noisy channel from a transmitter to a receiver is a branch metric computer for a Viterbi-algorithm based convolutional decoder. The Viterbi Algorithm is used very commonly to decode a convolutionally encoded sequence of bits transmitted over a noisy channel. In the heart of the Viterbi algorithm is a series of repetitive add-compare-select operations which accept as input certain metrics (termed branch metrics) computed on each received symbol from the demodulator. Viterbi coders and decoders as well as convolutional coding are described in "Mobile Radio Communications", by Raymond Steele, Pentech Press, 1992.

It is an object of the present invention to provide a telecommunications system as well as a receiver for the system and a method of operating the system and the receiver which improves the quality of received signals.

SUMMARY OF THE INVENTION

The present invention includes a method of operating a telecommunications system comprising the steps of: transmitting substantially simultaneously over separate first and second telecommunication channels a first and a second forward error correction coded signal, respectively, each of the first and second signals nominally containing the same user information; forward error correction coding at least a portion of the first signal; and forward error correction coding at least a portion of the second signal, the forward error correction coding of the portion of the first signal being different from the forward error correction coding of the portion of the second signal. It is preferred if the original user information may be reconstructed from either a combination of the two signals of the received signals and/or from each of the received signals. In one of the embodiments of the present invention, the signals are punctured whereby the bits which are punctured in the first signal are different from the bits punctured in the second signal. Preferably, the forward error correction code is a convolutional or a turbo code.

The present invention also includes a telecommunications system comprising: one or more transmitters and one or more receivers; the one or more transmitters including one or more forward error correction coders; wherein the one or more transmitters and the one or more forward error correction coders are adapted to transmit a first and a second forward error correction coded signal, each signal nominally containing the same user information, substantially simultaneously over separate first and second telecommunication channels, respectively, the forward error correction coding of the first signal being different from the forward error coding of the second signal. Preferably, the telecommunications system is a cellular radio telecommunications system. Preferably, the transmitter is in a mobile terminal of such a system and the receiver is one or more receivers in one or more cell-site transceivers. Preferably, the mobile telecommunications system uses spread spectrum techniques, e.g. the telecommunications system may be a Code Division Multiple Access (CDMA) system. It is preferred if the original user information may be reconstructed from either a

combination of the two signals of the received signals and/or from each of the received signals. In one of the embodiments of the present invention, the signals are punctured whereby the bits which are punctured in the first signal are different from the bits punctured in the second signal. Preferably, the forward error correction code is a convolutional or a turbo code.

The present invention also includes a telecommunications receiver system, comprising: one or more receivers comprising: a forward error correction decoder for substantially simultaneously decoding a first forward error correction coded signal and a second forward error correction coded signal, each of the first and second signals having a different forward error correction coding and each of the first and second signals being decodable to recover the same uncoded user message. Preferably, the receiver is adapted for use in a mobile telecommunications system. In particular, it is preferred if the telecommunications system uses spread spectrum techniques, e.g. it may be a Code Division Multiple Access (CDMA) system. It is preferred if the original user information may be reconstructed from either a combination of the two signals of the received signals and/or from each of the received signals. In one of the embodiments of the present invention, the signals are punctured whereby the bits which are punctured in the first signal are different from the bits punctured in the second signal. Preferably, the forward error correction code is a convolutional or a turbo code.

The present invention also includes a method of operating a receiver in a telecommunications system, comprising the steps of: receiving a first forward error correction coded first signal; receiving a second forward error correction coded second signal substantially simultaneously with the first signal, each of the first and second signals having a different forward error correction coding and each of the first and second signals being decodable to recover substantially the same uncoded user message; and decoding the first and second received signals to obtain the user message. It is preferred if the original user message may be reconstructed from either a combination of the two decoded signals and/or from each of the decoded received signals. In one of the embodiments of the present invention, the signals are punctured whereby the bits which are punctured in the first signal are different from the bits punctured in the second signal. Preferably, the forward error correction code is a convolutional or a turbo code.

The present invention also includes a transmitter system comprising one or more transmitters, the one or more transmitters including a forward error correction coder;

wherein the transmitter and the forward error correction coder are adapted to transmit a first and a second forward error correction coded signal, each signal nominally containing the same user information, substantially simultaneously over separate first and second telecommunication channels, respectively, the forward error correction coding of the first signal being different from the forward error coding of the second signal.

The present invention also includes a forward correction coder adapted to transmit a first and a second forward error correction coded signal, each signal nominally containing the same user information, substantially simultaneously over separate first and second telecommunication channels, respectively, the forward error correction coding of the first signal being different from the forward error coding of the second signal.

The present invention also includes a forward error correction decoder, for substantially simultaneously decoding a first forward error correction coded signal and a second forward error correction coded signal, each of the first and second signals having a different forward error correction coding and each of the first and second signals being decodable to recover the same uncoded user message.

The dependent claims define further individual embodiments of the present invention. The present invention will now be described with reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic representation of a telecommunications network with which the present invention may be used.

Fig. 2 is a schematic representation of a receiver in accordance with one embodiment of the present invention.

Fig. 3 is a schematic representation of a transmitter in accordance with an embodiment of the present invention.

Fig. 4 is a schematic representation of a decoder and combiner in accordance with one embodiment of the present invention.

Fig. 5 is a schematic representation of a decoder and combiner in accordance with another embodiment of the present invention.

Fig. 6 is a schematic representation of a decoder and combiner in accordance

Claims

1. A method of operating a telecommunications system comprising the steps of:

transmitting substantially simultaneously over separate first and second telecommunication channels a first and a second forward error correction coded signal, respectively, each of the first and second signals nominally containing the same user information;

forward error correction coding at least a portion of the first signal; and

forward error correction coding at least a portion of the second signal, the forward error correction coding of the portion of the first signal being different from the forward error correction coding of the portion of the second signal.

2. A method of operating a receiver in a telecommunications system, comprising the steps of:

receiving a first forward error correction coded first signal;

receiving a second forward error correction coded second signal substantially simultaneously with the first signal, each of the first and second signals having a different forward error correction coding and each of the first and second signals being decodable to recover substantially the same uncoded user message; and

decoding the first and second received signals to obtain the user message.

3. The method according to claim 1 or 2, wherein the forward error correction coding of the first and second signals includes convolutional or turbo coding.

4. The method according to any previous claim, wherein the first and second signals are digital signals and the forward error correction coding of the first and second signals includes puncturing.

5. The method according to claim 4, wherein the bits which are punctured from the portion of the first signal are different from the bits punctured from the portion of the second signal.

6. The method of operating a telecommunications system according to any of the claims 1, or 3 to 5, further comprising the steps of:
receiving the forward error correction coded first and second signals; and
decoding the first and second forward error correction coded signals to obtain the user information.

7. The method according to any of the claims 2 to 6, wherein the decoding step is preceded by a depuncturing step.

8. The method according to claim 7, wherein the decoding step includes one of:
depuncturing each of the first and second forward error correction coded signals separately, combining the first and second depunctured signals and then decoding the combined signal;
depuncturing each of the first and second forward error correction coded signals separately and then decoding and combining the first and second signals simultaneously in a multi-input decoder;
depuncturing each of the first and second forward error correction coded signals separately, soft decoding each of the first and second depunctured coded signals separately, and then selecting on a bit-by-bit basis from the first and second soft decoded signals.

9. A telecommunications system comprising:
one or more transmitters and one or more receivers; the one or more transmitters including one or more forward error correction coders; wherein the one or more transmitters and the one or more forward error correction coders are adapted to transmit a first and a second forward error correction coded signal, each signal nominally containing the same user information, substantially simultaneously over separate first and second telecommunication channels, respectively, the forward error correction coding of the first signal being different from the forward error coding of the second signal.

10. A telecommunications receiver system, comprising:
one or more receivers comprising:

a forward error correction decoder for substantially simultaneously decoding a first forward error correction coded signal and a second forward error correction coded signal, each of the first and second signals having a different forward error correction coding and each of the first and second signals being decodable to recover the same uncoded user message.

11. The system according to claim 9 or 10, wherein the forward error correction coding of the first and second signals includes convolutional or turbo coding.

12. The system according to claim 9 or 11, wherein the first and second signals are digital signals and the forward error correction coder includes a puncturing unit.

13. The system according to claim 12, wherein the puncturing unit is adapted so that the bits which are punctured from the portion of the first signal are different from the bits punctured from the portion of the second signal.

14. The system according to any of claims 9, or 11 to 13, further comprising:
a decoder for decoding the first and second forward error correction coded signals to obtain the user information.

15. The system according to claim 10, 11, or 14, wherein the one or more receivers comprise:
a depuncturing unit for depuncturing the received first and second forward error correction coded signals and for outputting the depunctured signals to the decoder.

16. The system according to claim 15, wherein the puncturing unit and the decoder are adapted for one of the following:
the depuncturing unit depunctures each of the first and second forward error correction coded signals separately and the decoder decodes each of the depunctured signals separately;
the depuncturing unit depunctures each of the first and second forward error correction coded signals separately, and the decoder comprises a combiner which combines the first

and second depunctured signals and subsequently the decoder decodes the combined signal;

the decoder is a multi-input decoder, the depuncturing unit depunctures each of the first and second forward error correction coded signals separately and then the decoder decodes and combines the first and second signals simultaneously;

the decoder includes a soft decoder and a combiner, the depuncturing unit depunctures each of the first and second forward error correction coded signals separately, the decoder soft decodes each of the first and second depunctured coded signals separately, and then the combiner combines the decoded first and second signals by selecting on a bit-by-bit basis from the first and second soft decoded signals in a selector.

17. The method according to any of the claims 1 to 8, or the system according to any of the claims 9 to 16, wherein the telecommunications system is a mobile radio telecommunications system.

18. The method according to any of the claims 1 to 8, or 17, or the system according to any of the claims 9 to 17, wherein the first and second forward error correction coded signals are spread spectrum signals.

19. The method according to any of the claims 1 to 8, 17 or 18 or the system according to any of the claims 9 to18, wherein the telecommunications system is a code division multiple access system.

20. A mobile radio terminal comprising the receiver system of any of the claims 10, 11, or 15 to 19.